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EXPERIMENTAL INQUIRY

INTO THE

EXISTENCE OF A SIXTH SENSE,

HERE CALLED THE

SENSE OF FORCE.

BY

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ON THE

EXISTENCE OF A SIXTH SENSE.

I.—UPON NERVES DISTRIBUTED TO SYNOVIAL MEMBRANES, AS BEING A SPECIAL SEAT OF THE SENSE DISCUSSED.

In the spring of 1844, my attention was first directed to the subject discussed in the present paper, from having been struck with the contrasting mechanism between the hand of a young Chimpanzee in Regent's Park Zoological Gardens, and that of man.

Though the homologies of the hand in the two beings are strictly numerical, to which indeed, in the bones of the extremities homology chiefly refers, yet, so far as function is concerned, no approximate analogy can be sustained; the thumb in the Chimpanzee being merely a counterpoise to the metacarpal region; but in man the same member is a counterpoise to the fingers, as well as to the metacarpal region.

From observing this marked proportional difference in the mechanism, and consequent function of the two instruments, I was strongly impressed with the conviction, that in man there exists some fixed and definite *geometrical* relations between the thumb, fingers, and palm of the hand, not common to the Chimpanzee. Of course, previous reading from various authors had led me naturally to suppose that *some* difference existed between the two, but not of that marked character which observation supplied.

Having been some weeks previously engaged in noting down a few reflections upon the structures and mechanism of the hand and foot in man; not having then, nor for several years after, read the beautiful and philosophical remarks made by Mr F. O. Ward upon the same instruments in his masterly, but disagreeably small work, Human Osteology; I was, from such previous exercise, the more disposed at once to attempt the reduction of theory to practice, and forthwith, after having arrived at my apartments, I tried a variety of measurements upon the hand with a pair of compasses, which resulted in demonstrating, at least, so I thought, the correctness of my previous hypothesis.

In the latter part of this paper, one series of these experiments will be given, the same which terminated in directing me to conceive the possibility, and finally, the probability of demonstrating by experiment, or induction, a sense hitherto, so far as the literature of Physiology is concerned, undefined and indeterminate, though most certainly suspected and anticipated; since it is well known that the late Dr Thomas Brown, from theoretical grounds conceived the possibility, or rather the probability of the existence of a sixth sense; and that Sir C. Bell, whose philosophic mind was fully awake to the value of such an hypothesis, especially from such a mind as Brown's (himself nevertheless having, independent of Brown, arrived at the same theoretical conclusion), resolved upon applying experiment to elucidate theory upon the true Baconian system of induction.

It need not be said in what a glorious result that rude, but best mode of testing theory terminated, since it ended in the discovery of that arrangement in the nervous system which has justly placed him, with Magendie, amongst the foremost of physiologists. But, whilst mention is thus made of Sir C. Bell, it ought not to be forgotten, that to his last days he imagined that he had disclosed to demonstration the missing sense, which he conceived, as residing in the nerves distributed to the muscular tissue; and hence he called it *muscular sense.*

Without, then, positively contradicting or denying such a sense in muscles, it is not, perhaps, going too far to say that, if it could have been reduced to experiments of a more definite and crucial character, it would have been received with more confidence, than hitherto has been its lot.

More recently, Professor Weber of Berlin has made a series of experiments, to determine the relative degrees of cold and heat to which various parts of the integument are susceptible, and also of *weight.* The experiments very closely accord with similar experiments made by the writer previously to his first seeing them referred to in Todd and Bowman's, and more recently in Carpenter's and Valentin's (by Brinton) Physiologies, and he can only wonder that the prosecution of those experiments did not lead the learned professor to results of a more comprehensive and decisive nature. But, as it is truly said, the "battle is not to the strong, nor the race to the swift," an inscrutable Providence lying between human perfections and accomplishments and *success*, which alone can explain, in the present case, if the writer should be correct, why the palm was not borne away by a more erudite and accomplished brother in the profession, whilst walking on the path where its branches lay scattered abroad for him to gather, and carry away.

Besides the opinions of these two worthy authors, and their disciples, little has been advanced of a precise character upon a sixth sense, as standing in relation to force, and therefore, further anatomical and medical literature need not be canvassed upon the subject.

It only remains, then, to state the extent to which this sense is adapted to determine different kinds or degrees of force; and also, in so doing, what are the mechanical arrangements requisite for the determining such distinctions in force; since, for *kinds*, the regulating agents are considered to be strictly mechanical, though applied by, and performed through, the medium of living material. Before proceeding further, I will endeavour to explain what is here implied by the terms *kind* or *degree* of force in relation to sensation or feeling; and afterwards endeavour to apply them to the sense herein maintained and discussed as demonstrating, or, at least, as favouring the position or idea of its existence, leaving to experiment the province of direct demonstration and complete induction.

In the first place, we are conscious of two different kinds of feeling in reference to force. The one is that of having power or strength to readily, or with ease, overcome the obstacle or resistance desired to be surmounted; as a child, in handling a light cane, or throwing a small marble, feels that he has power to overcome its resistance at once, and with little effort. This gives to the user the feeling or consciousness of strength or power over that object; and indicates the superiority, in such instance, of the muscular force over the gravitating to the child employing it. This, therefore, might be very appropriately called the feeling, or sense of *power* or *strength.*

On the other hand, by way of contrast, suppose a child, from ten to twelve years of age, has to lift a weight of from 28 to 42 lbs., he does it with difficulty, but by putting forth all his strength, he will accomplish it; or, in place of using two hands, he has to hold with one arm extended, a weight of from 3 to 4 lbs., the latter will be almost as difficult as the former, and in both instances the force employed to overcome the resistance will be put forth under circumstances of great effort and labour; and to the party so exercised, there will be a feeling or consciousness of great force being required to overcome the resisting body, which feeling is usually expressed by stating that the body is very heavy, or of great weight. Hence, this feeling or consciousness might be called the feeling or sense of *weight.*

Again, supposing an adult person applies his muscular force, aided by the mechanical arrangements of his osseous structures, to move a portion of rock, say 10 to 20 tons in weight, or to move a wall well built, and a foot and a half wide, he would be aware that neither object moved, though his eyes were shut; and, also, he would be aware that he was putting forth all the force his muscular system was capable of applying, to move the opposing obstacle, but without effect. This consciousness, or feeling within, of applying force, and applying it to its utmost extent, though no evident result follows in the body against which it is applied, might be called the consciousness or sense of *exercising* force, without any very accurate idea of the amount of that force, from the want of a standard whereby to judge.

In the cases above cited, a consciousness of *force* has existed in connection with muscular action. In the first case, there was great *excess* of muscular force to the resistance to be surmounted, and is popularly called *strength* or *power*. The second case presents us with an instance of *little* excess of force remaining, when the resisting body, against which it has been applied, is overcome; and in popular language, the feeling within is expressed by describing the body without, as being overcome with difficulty by the force applied, and is variably described as the resistance being heavy, or of great *weight*. Whilst, in the third case, the obstacle to be overcome by muscular force, being, by virtue of its gravity, or attractive force, considerably plus over the muscular force, remains unaffected by the external force applied to it; and in current phraseology is laconically described by the expressions, "it is too much for you;" "push away, my boy, you'll not hurt it;" or, "better save your breath for another time;" "it's no use trying;" all which expressions are only so many different ways of stating that muscular force is exercised, without any perceptible result following in the body against which it is applied.

In the foregoing sketch, relating to the effect of muscular action upon our feelings, I do not suspect that any will question the correctness of the statements therein advanced, or be disposed to deny, under the circumstances indicated, in a healthy person, that such feelings, as are there expressed, do exist; and that, in the occurrences of every day life, incidents are happening which lead to the expression of such feelings, when the incidents giving rise to them, place them before the mind, as here pointed out.

If, then, there are such sensations, etc., as have been indicated, following certain definite forms of muscular action, and those sensations are of a different nature from any with which we are supplied by the five recognised senses, what does it signify, but that there is a further source for our correct knowledge of the external world, than is to be found in the beautiful and exquisite channels of information, given to us in the orthodox senses—seeing, hearing, smelling, tasting, and touch?

But it will be said in reply, and with truth, that our knowledge of power or force, as Hume has affirmed, arises from our experience of known or observed phenomena being followed by uniform results. This the writer does not for a moment question; but for the knowledge of such facts, we are not indebted to sight alone, or to hearing, etc., etc., for both deaf and blind persons are equally conscious of possessing force, and in their actions accommodate themselves to the indications with which such feelings supply them. Hence, such abstractions leave the matter where they found it, and, in the present paper, their consideration may be respectfully declined.

Without, then, further ratiocination, a more varied mode of illustration may tend to throw the subject out into fuller relief.

Let it be supposed that there are five balls, each two inches in diameter, perfectly smooth, covered with a thin layer of caoutchouc, to prevent the conduction of heat, and painted of one uniform colour. The first shall be composed of cork, the second of dry oak wood, the third of silver, the fourth of lead, and the fifth of platinum; and furthermore, let each ball be *accurately* fitted into a cup or die. In this condition neither sight, hearing, smelling, tasting, nor touching, could detect the difference between one ball and another; but let the same balls be placed in the hand, and muscular force be applied to counter-balance gravitating, and immediately one mystery will be solved, namely, that although all had one colour and size, yet, that each of them was composed of different material. And why such an inward conviction? Evidently because a feeling exists that each requires a different degree of muscular force to overcome the gravitating, as compared one with the other. Or, in other words, that each had a different *weight* compared one with the other, and, therefore, that each must be composed of different material.

The inference of their being composed of different materials, of course, depends upon previous experience; but that experience rests upon a feeling, which the conscious party describes as depending upon his *acquired* or *past* knowledge of weight in bodies, in other respects outwardly very similar.

If, then, there is a feeling within which will decide so curious and certain a result, and which none of the five senses could so do, what is it but that a different and independent sense determines what they have failed to accomplish?

Having thus far pleaded for the existence of a sixth sense, sufficiently varied to claim for it the more weighty examination of results, elicited from an extensive series of experiments, I shall, for convenience sake, though the inference of there being a sixth sense be still *sub judice*, refer to it as existing and real, and shall, forthwith, enter into an inquiry as to the means used by nature to regulate and determine the different results experienced in the sensations, when muscular force is applied to counterpoise gravitating.

Though the present paper limits the inquiry, with regard to anatomical region, to the nerves distributed to synovial membranes of joints, yet no attempt is here made to demonstrate their presence by dissection. The more so, from the fact that numerous authorities, Sharpey and Quain in particular, who agree in inferring the presence of sentient nerves in bone, ligament, and synovial membrane from their sensibility to injuries and acute pain when diseased, especially synovial membrane; yet none of the authorities consulted have been able to trace the ultimate nerve fibres, or their modes of distribution, in these tissues. Nay, even in the very analogous structure of serous membrane to that of synovial, the same want of demonstration exists, though so susceptible to acute pain from the slightest amount of inflammation, or any other form of disease that may affect it. But the fact that none of these structures are subject to great pain when mechanically irritated, only shows that the stimulus applied to their structure is not adapted to excite their sentient powers; but that sudden injury of a mechanical nature can excite their sentient powers when properly applied, is most evident from the fact, that when loose cartilage is compressed between a joint—as the knee—most excruciating pain is immediately experienced.

It therefore being assumed that synovial membranes have sentient nerves, the inquiry of the present paper is limited to their *function*, and not to their course and distribution.

Again, on the other hand, it is not deemed necessary to discuss at length the *suitability* in the anatomical seat of nerves, distributed to synovial membranes, for taking cognizance of such a stimulus as force, when applied to their periphery, since, saving the sphincters, the occipito-frontalis, and a few muscles pertaining to the face, palate, œsophagus, the eye, and the ear, with their appendages, the whole of the muscles of animal life effect and complete their leverage force through the appliance of joints; and, therefore, whatever of force is applied by muscles, must, according to its amount, pass in like degree through these fulcra of bony structures; and, if nerves capable of taking cognizance of muscular force be there distributed, they will, by such locality, be best secured from mechanical violence, and most suitably placed to fulfil the office of their own peculiar function.

Without, then, any further remarks upon locality in relation to nerves of force, let the attention be rather directed to the mechanical arrangements that determine a recognition of *kinds* or *degrees* of force, as already explained.

The kinds or degrees of force which have been referred to, are recognised, it is conceived, by the different mechanical modes in which force is conveyed to the sentient nerves of joints, by the structures with which they are connected, as bone, fibro-cartilage, and true cartilage, the mechanical structure of each having a very definite and certain effect upon the mode or way in which force is made to impress the peripheral nerves.

As bone is the chief material through which muscular and gravitating forces are made to channel ere they reach the joints, a few remarks upon its mechanical structure, not microscopical texture, may be here very appropriately introduced.

Bony structure, as is well known, is hard, inelastic, or nearly so, and, according to its mechanical arrangement, presents different facilities for resisting external injuries; for instance, the long bones have two distinct kinds of mechanical arrangements, the shaft being composed of dense and compact material, whilst the extremities, as the femur and humerus, are composed of cancellous structure, or delicate bands of osseous tissue, arranged in an irregular net-like order, not very dissimilar to the siliceous matter or spicula of the poripheræ, denuded of their soft substance, by boiling in nitric acid. But the long bones do not all present this cancellated structure in equal degrees at either extremity, as the inferior extremity of the tibia, compared with the superior; the radius and fibula, as compared with the humerus and femur. The texture of the short bones is very variable with regard to the amount of cancellated structure; but, as a rule, it may thus be stated, that in proportion to the smallness of the bone, so does the hard compact external layer become more developed, and the cancellated interior become more limited, and less marked, and the larger the short bones are, the more of the reverse of this rule holds good.

The design of such structures or mechanism, in addition to that of resisting force by its compactness in the shaft, and warding off sudden concussions in the joints, by the expanded and porous extremities diffusing the force applied to them, has assigned to it the further important function of regulating the *direction* of force; as in the long bones, when a force is communicated at one extremity it runs along in nearly a straight line, till it reaches the opposite extremity, where, by meeting with the cancellous structure at that extremity, according to its extent and delicacy, so must the force assume some *new course*, not in relation to the course or direction in which it was first received, but in the direction which the cancellated osseous structure will permit it; for of necessity, the force will channel along its structure, it being denser in its structure than the interstices, which are occupied with some softer substance or fluid, either liquid or gaseous; and, moreover, from the very direction or interlacing of the cancellous structure, much of the force will come to composition and resolution before it reaches the surface of the joint itself.

But, besides the different structures in bone regulating the direction of force, there are two other structures of great importance in relation to the present inquiry; the first of these is *true cartilage*, a tissue both hard and elastic, and whose structure is composed of cells arranged in a columnar order, very closely resembling in their regularity certain basaltic rocks, as those of Fingal's Cave and the Giant's Causeway. These columns being arranged in a line with the long axis of the bones, will of course transmit force received by them from the articular surface of bones to the synovial membranes, in the same direction in which it is applied; since, in addition to its being regular in structure, it is also *hard* and dense to a considerable degree. Hence, where joints are only tipped with true cartilage and not with articular fibro-cartilage, as in the ankle and wrist joints—save the ulnar border of the wrist joint—the nature of the osseous structure entering into the joints need only be considered in estimating in what direction force would reach the synovial membrane, after it has left the osseous tissue to pass through the cartilage, before reaching that membrane. Since, in whatever direction it was received by the cartilaginous structure, in the same direction—or very nearly so—it will be transmitted to the synovial membrane.

The remaining structure we have to attend to is the *articular fibro-cartilage*, which is found bordering and overlapping the true cartilage in almost all the large joints, as the shoulder, hip, and knee-joints, etc. This structure, it need scarcely be mentioned, is anything but regular in its density or depth of substance, from within outwards, and is much more yielding and soft than true cartilage, though very elastic. The effect of such a structure would be, from its very softness and irregular density from within outwards, to vary and cast into some constant and uniform direction, any force which might be received upon its surface; of course, the completeness with which such new direction of force would be effected, would depend very much upon the thickness of the cartilage against which it first impinged; but this consideration, in a practical light, is of very little importance, since, in nearly every instance, where this substance enters into the composition of joints, cancellated osseous structure is associated with it, which has as great or greater modifying effect upon the direction of force, according to its amount in any particular joint, as has the articular fibro-cartilage, and therefore their modifying effect in relation to the *direction of force* in joints may be counted as unity, both tending to accomplish one and the same end. And it must be observed, that in large joints where the fibro-cartilage is the thickest, namely, at the circumference of joints, there also, namely, towards the external surface of joints, the cancellated structure becomes more dense and less spongy, and will therefore transmit force in the direction in which it is received more correctly than towards the centre or interior of the joint; but here the fibro-cartilage is a mere lamina or entirely absent, whilst towards the circumference, to countercheck the denser cancellated structure, it affords a deeper border for force to pass through.

Granted that cartilage, fibro-cartilage, and the different textures of osseous tissue have an effect upon the course or direction of force transmitted from the shaft to the joint, and that the combination of cancellated osseous structure at the extremities of bones, and articular fibro-cartilage, in its relative densities and thickness, tend to compel force, whilst passing through their structures into one uniform and constant line or direction, it will be very naturally asked, what is that line or course which force, so circumstanced, pursues? The probabilities are, that under such circumstances, it enters the joints in a *straight line*, or thereabouts, and the result of such direction, according to its intensity, is, that to the recipient, or conscious party, a *feeling or consciousness of power or strength is experienced.* Whilst, on the other hand, when the mechanism of the tissues entering into the formation of a joint, are so constituted as to admit of force entering into their structure assuming more directions or courses than one, that in such case, if the force, from any incidental cause, or opposing obstacle, shall be deflected from the straight line, or thereabouts, when travelling along the course of the long axis of bones, to an *oblique course*, or to a course almost at right angles to the line of the muscular force (or that nearly in a line with the long axis of bones), that then the conscious party will experience within, according to the intensity of the force, *a feeling or sense of weight.*

It is, then, upon the stability of the direction of force, in these two opposite and distinct courses, that the entire integrity, and demonstrability of the accuracy of the present hypothesis is based.

Before proceeding with any experiments, I shall at this juncture of my paper, between theory and practice, take the opportunity of pressing home the above positions of the direction of forces in the oblique, or nearly midway right angle course, and the straight line, or thereabouts, by a few illustrations and diagrams.

Fig. 1

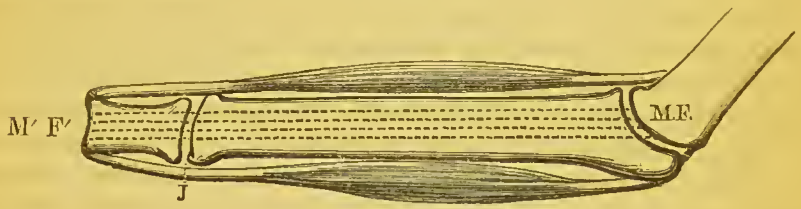


Fig. 2.

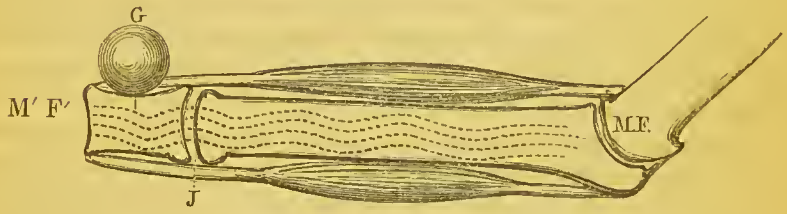
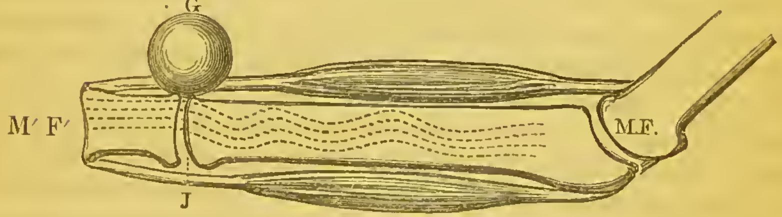


Fig. 3.



Suppose M F and M′ F′ represent either extremity of a rod whose continuous integrity shall be interrupted by an intersection, or joint, at the point J. Let cords extend from either extremity of the rod (above and below), endowed with contractile, or shortening powers. The cords contracting, or, in other words applying force, the residual force unexpended in the cords (*alias* muscles), will be expended in moving and regulating the position of the rod (or bone), and, in so doing, will run nearly parallel with the long axis of the rod, from the nature of the attachment of the cords; and, as a necessary consequence of the section or division of one part of the rod from the other (as by joint), by force being applied, as here described, the opposing surfaces will be brought into closer compact and opposition; and by being brought into opposition by a force acting, or channelling in a course parallel with the long axis, it follows that a force acting in the line of the long axis of a rod, will, whilst passing through, or across its sectional partitions, run in the same course or direction as in the remaining portions which are not intersected, which course being that of the long axis of the rod, the force passing through the intersection or joint will be in the line of the long axis also, or, in other words, in a straight line or nearly so, which line of force is here called the *line of muscular force.*

But supposing, as in figure 2, the muscular force, at the extremity M′ F′ is interrupted at the point G with gravitating force, or as in figure 3, at the point G J, with the same force, then the muscular force being checked or interrupted at the said points, according to the amount of the gravitating force which meets the muscular at a more or less acute or obtuse angle, but seldom diverging very greatly from the right angle, and also according to the *degree of counterpoising muscular force*, a *new* or *different line of force will result diagonal to the antagonistic forces.* The force resultant upon the combined action of gravitating and muscular forces, whose direction, from the position, or rather line of direction, maintained for muscular force alone, must, in the present case, be more or less oblique or angular, in its deflections from one portion of the rod or bone to the other, and in such direction it must pass through the joint or intersection herein set forth.

If, then, the opposite states of consciousness of force, as those of *power and strength*, or of *weight*, result from the *direction* in which force is applied to the surfaces of joints, it follows, for all experiments conducted with the view of proving such a position that they should have within them, to a greater or less extent, the elements essential to the sustaining and demonstrating such a distinct feature, and, if I may so say, crucial a result. Experiment, therefore, only remains to prove and sustain the hypothesis, that, to synovial membranes sentient nerves are distributed, whose function is to take cognizance of force, as applied to joints, whether it be gravitating or muscular.

The standard from whence the experiments will be measured, will, as a rule, be based upon the supposition that muscular force, unchecked by gravitating, is accompanied by a feeling or consciousness of power or strength, which, when counterpoised by gravity, is exchanged to that of weight, and in the following experiments the circumstances and conditions under which weight can be best felt will receive the greatest share of attention, whilst the contrasting feelings of strength or power shall not be overlooked.

Again, in attempting to repeat the experiments herein detailed it may be necessary to say a word or two. Force, like smell, taste, touch, etc., is very variable in different individuals, and unless due regard be paid to this part of the subject, no care in the conducting of the experiments will avoid a perfect failure. The best rule to attend to in this matter is to ascertain from the party operated upon, or the operator who may try them upon himself, whether he has a good idea of the weight of bodies by taking them in the hand, and trying to weigh them; if he has a good idea, then the experiments, *cæteris paribus*, will succeed, but if he is deficient upon this point, the probabilities are, that they will fail.

Moreover, in prosecuting these experiments great care will be required in attending to the details given with each experiment, and much patience in repeating them two or three times, until some facility is acquired in readily seeing through the conditions requisite for their successful prosecution.

In order that an experiment may determine the point which it is designed to elicit, it is necessary that the object to be experimented upon be somewhat understood in those parts in which the end to be elicited is closely connected; and in the present instance an examination of a few leading points connected with the mechanism and direction of forces pertaining to the joints, may be found convenient and suitable; each joint, in its course, receiving sufficient examination to enable the experimenter to judge of the value of any result obtained from such an ordeal as that of careful experiment.

Suppose we commence with the foot.[1] So far as function is concerned, it may be said, that the foot possesses three fixed points or axes, for the weight of the body to rest upon, namely, the heel, or posterior axis; the ball of the great and second toes; and the cushion, or ball of the fourth and fifth toes, especially the fifth or little toe, the former of which might be called the *internal*, and the latter the *external* axes of the foot.

It is from this mechanical arrangement that man is enabled to stand upon one foot for an indefinite period; and to recover himself when he has in some degree lost his balance. Birds, likewise, are enabled to stand for an indefinite period upon one leg, from a similar principle of mechanism pertaining to their feet, as in most aquatic species, etc.; the tarsal terminus constituting the posterior axis, and the internal and external toes the anterior axes, regulated by the middle toe; but where such arrangement is not made, as in the psittacidæ, or parrot family, standing is difficult, or almost impossible. So likewise the ouran-outan (*alias* orang-outang), is obliged, in progression, to preserve its balance by a stick, from the absence of the heel (the os calcis being, in that animal, very small), and also from the want of a double arrangement of axis to the anterior part of the foot, the weight being chiefly received upon the external border of the foot, or rather, modified hand; and as for standing upon this instrument for any length of time, the execution, with such a mechanism, is impossible; for, whilst two axes, or fixed points (with which signification the word axis is here used) are sufficient to balance and rest the superincumbent weight placed upon them, with the ability of changing position by throwing the body upon one or the other entirely; as when the body rests upon the heel and great toe, by raising the heel the body falls entirely upon the ball of the great toe; yet to preserve one position for a very limited period a second axis is necessary, owing to the variety of points from which muscular force is applied during the alternate contraction and relaxing of muscular structure; and when standing

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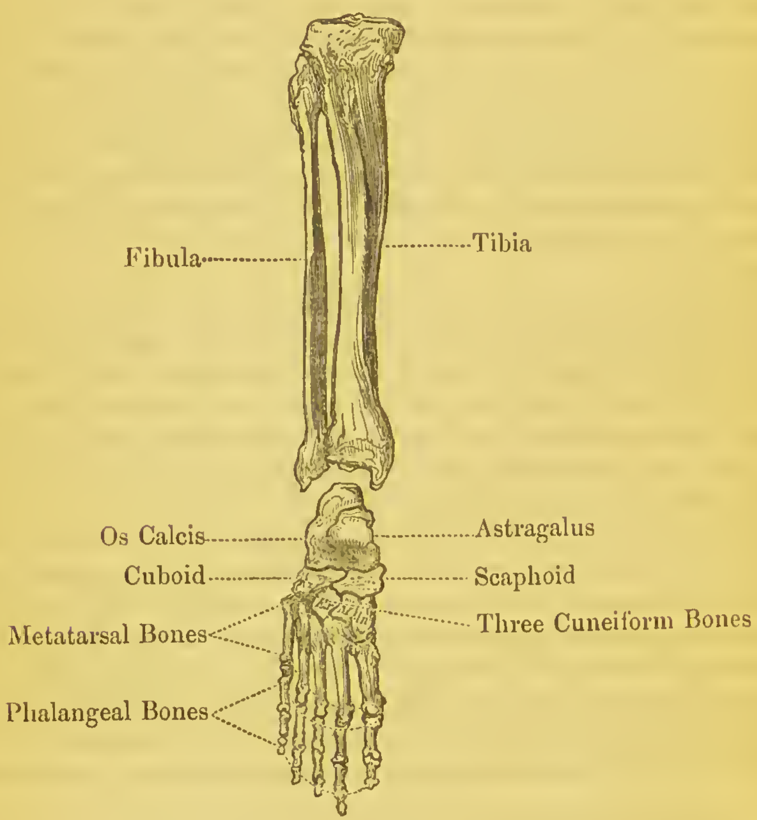
[1] Before entering upon any remarks relative to the mechanism of the foot, I feel obliged to express my deep regret, that, from the nature of the subject matter of this paper, I am not capable of employing the improved *descriptive* nomenclature which its anatomical relations have naturally suggested to Mr F. O. Ward, when describing the osseous structure of the foot in his work, already referred to, on Human Osteology; but this paper was written previously to my having perused Mr W.'s work, and the nomenclature, as here supplied, being adapted to function, in relation to the sense maintained, and not to descriptive anatomy, upon mature consideration it appeared best to me to persist in what I had first written, than to alter it for courtesy's sake, and at the expense of making the subject less intelligible; while at the same time, I do not in anywise desire to claim any superiority, far less priority, in giving, in many respects, an almost identical description of the functions and motions of the foot.

Fig. 4.



on one leg is performed with ease, and for long, as in birds, and also in man, a third, or regulating axis is indispensably necessary.

The relation which these axes have to the sense of *force* will appear evident when we come to examine their osseous connections. But it may here be remarked, that the pads or balls of the several axes, consisting for the most part, of dense cellular tissue, in which is enveloped variable quantities of adipose tissue, serve the important function of checking concussions, from the weight of the body falling suddenly upon those parts which their structure is adapted to protect; yet, as these pads have no direct connection with the osseous arrangement of the foot, further examination is unnecessary.

As the astragalus is that bone through which all weight, or force, from the body is transmitted to the foot, and also, as it is the common receiver of all force applied to the foot, as by muscles, to raise the body from the surface upon which it rests, the tibio-astragaloid articulation being the communicating medium, it may be well, at this part of the descriptive outline, to mark out the *order* in which these several axes are impressed during progression, and with it the probable amount of weight received by the articulation referred to from the sucessive axes.

The posterior axis, situated on the posterior border of the os calcis, receives the weight of the body first, when the foot is projected forwards and placed upon the ground, as in the act of walking; whilst the anterior external axis of the foot reaches the ground nearly simultaneously with it, so that the force of the body and consequent weight is divided between them. These two axes form the first firm resting point or platform for the body to rest upon; whilst, by a combination of movements in the lower extremity, but especially by the combined contraction of the solens and gastrocnemiens muscles, the weight of the body is thrown off the *external* axis to the anterior *internal* axis, or ball of the great toe, and the heel or posterior axis. These two axes—the posterior and anterior internal—preserve their sustained function to the body but for an exceedingly limited period, the whole weight of the body being speedily thrown upon the anterior internal axis only—the immense force applied between the tibio-astragaloid articulation and the ball of the great toe being received upon a powerful arch or bridge, whose summit is immediately over the scaphoid bone. In these successive movements, by careful examination, it will be perceived that the heel or posterior axis has a most important function to perform as a balancing or regulating axis, whilst the direction of weight from the body is transferred from the external to the internal anterior axis; or that axis which is destined, in successive movements, to receive and sustain the whole weight of the body during the period occupied by the opposite limb in wielding itself from behind forward to be planted upon a like posterior axis or heel, to undergo like successive motions, till progression ceases in rest.

From the foregoing remarks, aided by a consideration of their osseous connection, it will be perceived that if the weight of the body be received upon the posterior axis of the foot, though the os calcis is so firmly and closely articulated with the astragalus, yet that the whole force is not transmitted from the calcis to the astragalus, and thence to all parts with which the astragalus is articulated; since part of the force is directly transmitted from the calcis to the cuboid, and to all bones articulated with it, especially to the fourth and fifth metatarsal bones. Consequently, if sentient nerves distributed to the tibio-astragaloid articulation, give consciousness of weight, the *same weight* applied to this axis will be less perfectly determined than where it is more directly transmitted, especially as it is brought early to composition by the force or weight of the body being speedily received upon the external axis, towards which point it is travelling from the heel, at the time the weight of the body is being received upon this axis—the external.[1]

Again, the anterior external axis, including the heads of the fourth and fifth metatarsal bones, does not transmit force applied to it by a direct line of osseous continuity to the astragalus, but through the medium of the os calcis; by which means, much of the force applied to it is expended in the os calcis, etc., before reaching the astragalus. Hence, only a limited amount of force applied to the anterior external axis, reaches the tibio-astragaloid articulation.

Lastly, the anterior internal axis, situated between the heads of the first and second metatarsal bones, but chiefly occupying the head of the first metatarsal bone, transmits its force directly to the astragalus, through the medium of the internal and middle cuneiform bones, and the scaphoid. (The articulations of the tarsal bones with each other, admit of such slight motion, that their ability to transmit force in the direct line in which it is received, is here taken as a groundwork for estimating the course and distribution of force, in the same way as a continuous solid structure; making suitable allowance for the amount of cancellous structure existing in the centres of these bones).

But before we leave this mechanical subject, it may be asked, What do I make of the third toe? Suppose we view it as a communicating and moderating medium, directing the force applied to it, according to the conditions in which it may be placed, a little more to the external axis at one time, and at another time a little more to the internal axis, of the foot; since the peculiar manner in which its osseous relations are wedged in between the cuboid and scaphoid bones allows, if the conditions are supplied, this variable way of directing or shifting force—in the same manner, but to a much more limited extent—as the middle claw of the bird is applied to equipoise and adjust the *course of force*.

Having thus far examined a few leading points in the mechanism of the foot, it may not be amiss to make a few remarks relative to the synovial membranes pertaining to this instrument.

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[1] Vide Fig. iv.

In examining the synovial membranes pertaining to the foot, as well as those connected with all other parts of the body, their relative importance to the sense under consideration, must not be measured by the superficial area any particular sac may present, but by the apparent amount of sensibility upon injury or in disease. Thus, for instance, from the few scanty opportunities the writer has had of observing indications of pain, during operations, etc., upon the foot, he is disposed to think that the calcaneo-cuboid and scaphoid synovial membranes, and the synovial sac dipping between the scaphoid and cuneiform bones, possess very little sensibility, if any; but that those connected with either extremity of the metatarsal bone of the great toe, possess considerably more. Indeed, many of the smaller synovial membranes placed in the phalangeal joints, and also those in the tarsal and metatarsal joints, saving those connected with the great toe, appear, from the effects of continued pressure and friction, to be worn through, or absorbed, and where such process has not been completed, their dry and almost imperceptible structure, indicates that much of their function is obliterated. Hence, after the age of 40 years, or thereabouts, and in many much earlier, the dissection and tracing of these membranes in the foot and other parts, is impossible; and, as a consequence of this destruction of structure, we shall find, as a rule, that young men and boys, from 15 to 30 years of age, possess the power of testing the value of things by weight, better than those of more advanced years. Lastly, those joints which possess the largest amount of synovial membranes, *in conjunction with the greatest amount of freedom of motion* in the joints which they cover, will be found endowed with the highest amount of sensibility to mechanical injury, and, also, are by far the most painful when inflamed. These latter remarks apply with much force to the synovial membrane lining the tibio-astragaloid articulation; and in experiments pertaining to the foot, the testing point in relation to the sense of *force*, will have especial reference to that joint, or rather, membrane. With these remarks, we may, I think, with propriety, detail a few experiments.

A poker, or pair of tongs, especially the former, is the only instrument required; also, to prevent pain from direct contact of these instruments with the skin, and to check the sensation of excess of heat or cold, it will be necessary to have the feet covered with soft and pliable leather shoes, or easy boots.

Being seated on a chair, let the foot be slightly advanced beyond the perpendicular of the knee. Let the knee and foot be everted, or turned outwards, *as far as is found comfortable* to the party to be experimented upon, then let the poker (or tongs) be placed between the heads of the fourth and fifth metatarsal bones; with the poker thus adjusted, let the foot be gently raised and depressed from the heel, but rather quickly, but not so as to contract the muscles rigidly. In this position, by so moving, *considerable* weight will be felt. Next, revert the experiment. Retain the poker in its original position, but *invert* the foot, and slightly depress the *external* border; then elevate and depress the foot, so adjusted, as before. In this position, *very slight* weight will be felt as compared with the foregoing.

Again, place the foot in the position *first* described—everted, and apply the poker between the heads of the first and second metatarsal bones, being the site of the anterior internal axis. Next, gently raise and depress the foot as before, in this position *slight* weight will be felt. Revert the order of experiment. *Invert* the foot, depressing its external border as before described, still retaining the instrument over the internal axis, raise and depress the foot, when the feeling of weight will be found very considerable, as compared with the same weight felt with the foot everted.

What relation, it is asked, have the preceding experiments in elucidating the hypothesis here discussed? As follows. The interior articular extremity of the *tibia* is divided by a slight ridge about its middle, the internal half of which is more *depressed* than the external, and, of course, as compared with the internal, the external half is *elevated.* By *everting* the leg and foot, the tibial articulation, in its external half, is depressed; whilst elevating the external border of the foot, and depressing the internal, the external surfaces of the tibio-astragaloid articulation are made to closely approximate each other, and the synovial membrane of the opposing surfaces is thuswise made to approximate its own surfaces most closely. The consequences of this are, that the force, whatever it may be, passing through the joint, is uninterrupted while passing from one surface to the other; and, therefore, if *direction* of force has any thing to do with the sensation experienced in the joint, in such case, both synovial surfaces will be alike, so far, at least, as the *line of direction* is concerned. At the same time, from the nature of a shut sac, the force must be received upon one surface from behind, and on the opposite in the front; whilst, moreover, from two surfaces receiving force in the same direction, and nearly at the same instant, in the place of one surface, a larger sentient surface is exposed to the influence of its appropriate stimulus. But when the foot is inverted, and its external axis depressed, the external portion of the tibio-astragaloid articulation is widely separated from its opposing surfaces; and for a force to reach the internal portion of the articulation, in place of the external, a circuitous route must be taken, involving much expenditure of its original impetus, by the force having to cross the foot, and, in so doing, meet with friction sufficient to bring much of it to composition ere it reaches the principal sentient articulation, which will amply account for the diminished feeling of weight, when the foot is inverted, and a poker, or any other instrument, is resting over the external pedal axis.

When the weight is placed over the internal axis of the foot, by everting it, the internal articular half of the tibia, antagonizing with the opposed astragalus, is removed considerably from the adjoining surface; hence force or vibrations, from this axis to the astragalus, have, from this unfavourable position, their intensity greatly diminished. But by inverting the foot, the opposed surfaces are brought into close approximation, and the force travelling so directly from the internal axis to the astragalus, the feeling of weight will be slightly increased to that felt in the most favourable position on the external axis, but the difference will not be perceived unless some little practice has secured accuracy.

Of course, it need scarcely be added, that in the foregoing experiments, gravitation has been used to counterpoise muscular force; and, as a natural consequence, the direction of force would be in the diagonal of either of the forces taken separately, and would reach the joint in *an oblique* or wave-like direction.

Let me here introduce one more experiment relating to the anterior part of the foot. In this experiment, let a poker be placed over the *middle* of the first metatarsal bone, when the foot is slightly inverted, and raise and depress the foot as before. In this position, the weight experienced will be greater than in any other part over which the poker may be placed on the foot; since here we have the muscular and gravitating forces antagonizing each other in a *direct line* with *three* synovial membranes; the synovial membranes covering either extremity of the first metatarsal bone, each of considerable extent in surface, and the synovial membrane of the ankle joint. The force so applied, will, of course, impress these articular surfaces better than when applied at any other angle of inclination than that of the direct line of transmission.

Apparent exception to the Experiments already detailed.

“ If a poker, tongs, or any suitable instrument, be placed upon the internal or external anterior axis of the foot (little or great toes), and the foot, with its superimposed weight, be raised upon the heel, and then be allowed to *suddenly* fall upon the ground (in the same way as conceited minions in music attempt to beat the time for their superiors) by successively raising and depressing the foot, the consciousness of great weight will be experienced in the foot, especially about that axis upon which the instrument rests.”

The feeling just described, might be supposed to arise from stronger vibratory impulses being conveyed to the several synovial membranes of the foot, especially to that lining the ankle-joint; and the consciousness of increased feeling in the immediate neighbourhood, might be referred to some illusion of the sense under consideration. But the writer has no such conviction about the matter; therefore, he will here simply state, that in another paper, if spared, he shall attempt to show that the sense of force, as here maintained, has for its principal anatomical seat synovial membrane; but, from the ends its information or function are intended to secure, there are occasional departures from this general seat of distribution, the integument of the palm of the hand, the sole of the foot, and several other parts, being examples of the same.

Concerning the heel or posterior axis, it may be said that an experiment cannot be easily performed upon it, but an attempt may be made, which will elucidate the subject in a trifling degree.

Suppose, to be homely in the description, an individual, in walking across a room, has trod with his heel upon a small piece of bees' wax, and finding it difficult to scrape it off, proceeds to balance himself on the opposite foot, whilst he flexes the leg upon the thigh of the same foot, and gently extends it for the purpose of removing the wax. Now, this last motion, or extension of the foot, is not wanted; therefore, we will suppose that the individual has troubled himself in adjusting his body, as above described, for the purpose of seeing whether or not the back of his shoe has been properly cleaned. This, then, will give the exact position here wanted. If, then, an individual, with the foot and leg thus adjusted, take a poker, and place it opposite the posterior surface of the os calcis, he will experience but slight weight at first; but after it has remained over the os calcis for some little time, the feeling of weight will greatly increase. Next, alter the position, and place the poker superiorly upon the tendo achillis, immediately opposite to the tibio-astragaloid articulation, when the feeling of weight will be felt at once, and *greater* than if placed above or below this situation.

The cause of this difference in the feeling of weight in the two approximate positions is obvious; when the poker rests upon the posterior inferior border of the os calcis, the greater part of its weight or force passes along the os calcis to the cuboid and metatarsal bones of the fourth and fifth toes, but part of this force not finding a ready transit from the cuboid to the metatarsal bones will be deflected, in some measure, according to its angle of incidence, towards the articular surface of the astragalus, and there occasion an increased consciousness of weight; whilst part of the weight will travel more directly (than by a course of deflection) from the calcis to the astragalus; nevertheless, whatever course force may take from the calcis when the foot is adjusted, as has been described, it is evident that before it reaches the principal sentient articulation of the foot, namely, that of the ankle-joint, much of it will have come to composition and resolution ere it has reached that point. But the reverse of all this holds good when the weight is placed exactly opposite the ankle-joint posteriorly, where both forces are brought into collision at once, and before their resultant or oblique force has been expended by friction or composition; hence, according to the present hypothesis, the greatest weight ought to be felt here, and also most speedily, which exactly accords with fact.

Here terminate what experiments I have to submit for examination on the foot. The attention will next be directed to the knee and hip-joints.

The knee-joint is by far the largest, and has synovial membrane more abundantly distributed to it than any other, joint in the body; here, then, we should suppose that a consciousness of a feeling of weight would be above all others the most apparent; but in this respect we shall be greatly deceived—since the mechanical relations of this joint check the manifestation of the feeling of weight in the sense of force, and supply those of strength, or resistance, only.

This peculiarity may be set forth in the following manner:—The femur is very much more constricted in the shaft than at its extremities, especially its inferior condyloid extremity; moreover, the shaft consists of firm and dense osseous structure, the condyloid extremity, in its interior, of spongy or cancellated osseous structure. The consequence of this contrast of texture must be, that whilst the weight of the trunk is sustained by the arched shaft of the femur in a narrow space, all unexpended force which passes from thence to its inferior condyles is distributed over a much wider surface, the arrangement of the cancellated structure of which affords great facilities for the widely diffused force to come to composition, whilst channelling along rows or bands of osseous tissue placed at opposite angles to each other. Furthermore, though the osseous tissue covering the articular surface of the condyles is very hard and dense, yet, like its antagonist in the tibia, it is *exceedingly thin*, and therefore the two opposing surfaces, the femoral and tibial articulations, present no sufficient barrier for the resisting, or regulating of forces, impinging against them. But, by their diffuse spongy tissue, a ready path is opened both for the diffusion and expenditure of force; neither is it till the force is aggregated or compressed into the much narrower and less cancellated structure of the tibio-astragaloid articulation that, when the body is raised and depressed successively upon the anterior extremities of the feet, with the knees in a semiflexed position, that we experience any sense of weight, at which time it may be distinctly felt in the ankle-joint and ball of the great toe.

But if the knee-joint presents a structure, the osseous mechanism of which is peculiarly adapted to diffuse and expend force, from the very nature of such mechanism, as has already, in the introductory remarks, been referred to, it is incapable of conducting any force to the articular surface in the same direction in which it was first received, but in some course or direction which the mechanism of the structure of the osseous tissue, etc., of the joint compels it to assume, *independent of previous bias.* Therefore, it follows, that the feeling experienced in the joint itself must obey the indications of the *forced or compelled bias* which its structure is adapted to secure, and not that which external appliances appear likely to determine. (Of course the remarks relative to fibro-cartilage, as well as to the spongy tissue of the bony framework, already detailed, apply to the joint at present under consideration).

To throw the matter into fuller relief, contrast this with the ankle-joint, and the articulations of the metatarsal bone of the great toe, unprotected with articular fibro-cartilage, with the additional advantage of the constricted and comparatively dense inferior extremity of the tibia; so constructed as to gather the widely distributed force at its superior extremity into a narrow surface inferiorly, and that too covered with simple cartilage, whose line of direction being continuous with the long axis of the bone, the mechanism of this structure is in every way adapted to perpetuate motion in the same direction in which it is first received.

The same remarks, relative to the knee-joint, apply with almost equal force to the *hip*-joint; since, though the rim of the cotyloid cavity, and the head of the femur, have not so widely diffused a cancellated structure as the bones entering into the knee-joint, yet the obliquity of the surgical neck of the femur to the shaft of the bone will completely destroy the precise direction of pre-existing force channelling along the shaft. Again, the peculiar mechanical arrangement of the pelvic bones, and the variable angles at which force will meet, and, by counterpoise, be brought to equilibrium, or nullity, ere it reaches the hip-joint, greatly tend to limit force; while the residue, not so composed, will, by friction, be much checked in rapidity, and reduced in original impetus, and will reach the joint, for the most part, in one common direction according to the course any force may have to take along the pelvic bones, and not in relation to the direction in which force is first received upon any part of its firm framework. The result of this compulsion, in relation to the course or line of force, will be, as stated in an early part of this paper, that in place of a consciousness of weight being experienced in the hip or knee-joints from any force reaching, or being applied to, their articular surfaces in an oblique direction, a feeling of *strength* or *resistance* will only be felt.

Notwithstanding the special pleading in the foregoing paragraph, it will nevertheless be asked, is it not possible to induce by experiment a consciousness of *weight* in these joints, as an antithesis to their normal feeling, and so render the hypothesis of one sense presenting the combined function of opposite states of consciousness, as that of resistance or strength, and of weight, more determinate, and so place the hypothesis upon the broad foundation of experiment and induction? To meet this very natural inquiry, I will endeavour to illustrate the hypothesis by only one experiment for either joint.

I will commence with the knee. If I extend the thigh and leg *backwards*, and place the foot, or rather the toes, upon a chair or a high stool, taking care to hold by some fixed point, lest, in such an unnatural position, I lose the balance in the opposite limb; and, if in this position I place a poker or any other suitable instrument in the popliteal region, exactly opposite the joint, I shall feel the full weight of the instrument; but if I place the same a little above *or below* this site, very little consciousness of weight is experienced.

This, then, is almost the only experiment that I have been able to devise for this joint; and, since it appears to be a pretty conclusive one, and not open, as far as I can see, to any objection based upon the conditions required for a conclusive experiment upon the present hypothesis, I need not, if I could, proceed any further with multiplying experiments upon this joint. I shall merely add, that in the foregoing trial, all the provisions made in the mechanism of the joint to throw force into one common and arbitrary course, independent of the manner or course in which it is received, are here obviated; and the diagonal of the two forces—gravitation and muscular force—will reach the sentient surfaces of the joint little expended, and at that line of obliquity which is here supposed to be well adapted to give to the nerves of the part a suitable stimulus for exciting the feeling of weight.

As regards the hip-joint, it will be perceived that in devising any experiment for it, difficulties surround us on every side from the peculiar position of the articulation; but here, as before intimated, one experiment may be set forward.

In performing an experiment upon the hip-joint care must be taken as to the position of the party to be experimented upon. First, then, let the party be seated in a chair, and leaning backwards; let the (right?) leg be semiflexed and resting upon the ball of the great toe, very much in the same position as a sociable man will take a little child and place it upon his thigh or knee, and give it—as the little creature will call it—a ride. In this position let a poker be placed external to Poupart's ligament, and immediately below the inferior anterior spinous process. Thus adjusted, let the party gently raise and depress the limb upon the internal axis of the foot (ball of great toe), when a considerable degree of weight will be felt; place the same instrument superiorly or inferiorly to the afore described position, when scarcely any weight will be felt.

Here we have not quite so decisive an experiment—from the difficulty of performing it—as that upon the knee-joint, from the conformation of the joint itself. Yet here, as elsewhere, in that part where the two forces—muscular and gravitation—can be brought to *antagonize* with each other—from the variable angles at which they may be brought in contact with each other—we have the consciousness of weight most apparent.

In suggesting these two experiments it may be well to add a caution or two in case any attempt be made to vary them. The first caution has relation to the hip-joint, and comes within the category of an *apparent exception.* Supposing a weight, as a poker, be placed internal to Poupart's ligament at variable points, till it reaches the mesian line over the symphisis pubis; the intensity of feeling or consciousness of weight will be found to gradually increase till the mesian line is attained, where it is the greatest, and gradually diminishes as the object is removed external to that point. The intensity in the feeling of weight, in this region, is owing to the distribution of nerves of force to the integument, at least so the writer thinks, and he will, as before stated, endeavour to examine the matter in a subsequent paper.

The other caution refers to the knee-joint. Suppose an individual, after trying a few experiments, conceives that some more decisive ones might be brought to bear upon the subject, and in his diligent zeal tries to realize the weight of the trunk by raising and lowering it, by gentle flexion and extension of the lower extremities, he will find, by so doing, that a sensation of weight is experienced in the ball of the great toe and ankle-joint. But could not, he will say, a similar sensation be induced in the knee-joint? Suppose then, again, that the same individual, to limit the weight of the body to the knee-joint as much as possible, and so make the trial more conclusive, balances the body upon one leg, flexing the trunk upon the thigh, and the thigh upon the leg, and by very powerful contraction of the muscles he raises the body into the erect position. Contrary to his feeling any sense of weight in the joint, if it is more than he is equal to, the exertion may at the time, from too great pressure, produce aching or pain in the joint, but if he is quite equal to it, whilst raising the body, he will only feel a sense of resistance or strength, which, according to the conditions under which this sense responds to the stimulus of force in the knee-joint, ought to be the case. But, *as soon as* the extension ceases, a feeling of aching and weariness immediately follow, sufficient to drown all other previous feeling in the limb. Yet, as experience has taught us that this feeling follows great muscular exertion, or slight and *long* continued, it is naturally supposed that here is the sense which supplies us with a consciousness of force. But the consciousness is rather of a negative character than positive, for, whilst action or contraction in muscles is going on, vigour and strength are experienced, but when that has ceased, *and not until then,* weariedness is experienced; and this feeling of weariedness is experienced most intensely over the region of the fascia lata; but more or less *all over the body,* especially where fascia is the most dense.

To enter into any detail upon this last mentioned feeling in the present paper would be quite out of place, but the writer may state that he has no reasons for supposing that the nerves pertaining to the sense of force have any thing to do with it, beyond their being a kind of contrast, and, if he may so speak, a counter-compeer to the same. The writer cannot well conceal his impression that it was from the feelings of weariness, as just described, that Sir C. Bell inferred there was a muscular sense.

To return, though a little out of order, for brevity's sake, we will consider the shoulder-joint. This joint presents all the peculiarities for the distribution of force, and of throwing it into one common course, which the two preceding joints have presented; but, from the manner in which it is protected by the acromion and coracoid processes, I have not been able to devise any experiment whereby the feeling of weight can be induced, the feeling of vigour or strength being alone felt.

In relation to the three joints, knee, hip, and shoulder, it is worthy of remark that we are daily in the habit of judging of the activity and vigour of the muscular system, in any given individual, by observing whether the knee and hip-joints are tightly compacted together, and the shoulder-joints appear neatly and closely approximated. This arises, apparently, from the fact that every one, when about to put forth much strength, has a feeling within of these parts being so adjusted, and he naturally applies his own convictions, or feelings, in observing and measuring others; thus a popular standard for physical force has its foundation in physiological induction.

The next part to be examined is the spinal column. The transverse processes of the vertebræ are lined or tipped with synovial membrane, but, from the very limited amount of motion, especially in the dorsal region, this membrane is scarcely discernible. But in the cervical and lumbar regions the motion is not so limited, and the synovial sacs are consequently better developed. Here nervous tissue may be supposed to be but very slightly supplied, yet to the integument of these parts I imagine that the nerves of force are well developed, so that when a weight is placed on the lumbar region it is very soon felt, but not, I presume, from nerves distributed to the synovial membranes of the transverse processes—probably they may assist. The same remarks pertain to the cervical region, till we reach the atlas in its articulations with the axis and occiput, at which parts, especially with the occiput, synovial membrane is very freely distributed, and appears to be always well lubricated with synovia.

If, then, a book, or solid piece of wood, say the size of Kidd's Bridgewater Treatise, be made to rest across the cervical region, or be balanced upon one of its angles, and, when the neck is bent, be placed in succession from the seventh to the first cervical vertebræ, at short points of distance from one another, it will be found that the feeling of weight attains its maximum opposite the first cervical, where weight is felt to no inconsiderable degree, when the experiment is carefully conducted.

Again, if any experiments are tried in the dorsal region, where no feeling of weight is experienced, from a book, or any other suitable object, being made to lie or rest with its long border upon their spinous processes; yet, if the book is laid *flat* upon the back, over the dorsal region, and, by being so placed, imparts part of its weight to the ribs bending outwards from either side, that weight will be distinctly *perceived.* This arises from either of the articular surfaces of the heads of the ribs, resting upon corresponding facets in the bodies of the vertebræ, being tipped with synovial membrane; and such an apparent exception only tends to confirm the hypothesis advanced.

Next in order comes the head. The experiments upon this part appear to be deserving of particular attention, and tend, as much as any hitherto advanced, to confirm the hypothesis here maintained.

Exper. I.—If a weight, say a polished stone, or a piece of lead, 2 lbs. in weight, and tipped with leather, be placed in the mesian line of the head, at the saggital suture, *opposite to the condyles of the occiput*, it will be found that a consciousness of weight, greater than at any other part of the head or neck, will be experienced, and also, that it will be felt more quickly than elsewhere. If the nerves distributed to synovial membranes supply us with the sense of force, or a *consciousness* of its existence and degree, then, in any given region, where such nerves are distributed, over that part where force will channel the quickest, and with the least expenditure by friction to the seat prepared for its perception, there, if the premises are correct, shall we feel it the earliest and the most intensely. Perhaps it need scarcely be observed, that the cranial bones, from their thinness and compactness, are better adapted to convey force, considering their extent of surface, than any other in the body; whilst the loss by divergence, when weight is placed in the centre, on the top of the head, is greatly compensated by this region being balanced upon equilateral condyles. These, by being supplied with sentient nerves, adapted to test force on either side of the centre of gravity of the head, act the part of a pair of scales, in guiding and directing muscular action how to apply its force in adjusting the organ placed under its protection.

Exper. II.—Place the same weight, as was used in the first, on the frontal bone, as far anterior as can be accomplished with convenience, when but slight weight will be felt; but retain the weight for some time in the same position, and the feeling of weight will gradually intensify, but will never attain to the same degree of intensity as in the first experiment. The expenditure of force by friction, before reaching the condyles, sufficiently accounting for such diminution; and its more tardy recognition is equally satisfactorily accounted for, from the force, in this instance, having to travel obliquely, and also at a greater distance from the seat of perception than in the former case. Such a contrast, under circumstances so similar, can, I think, only be accounted for by an hypothesis, either similar or identical with that here maintained.

Exper. III.—Let the same weight be placed on the upper lip, immediately below the nose, the countenance looking upwards—in this position the amount of weight experienced will be little different to that in the last experiment; but it will be *much sooner felt*, since it has a much shorter course to run along the zygomatic arch to the occipital condyles, but, from the narrowness of the bridge or arch, much of the force must be expended in other parts ere it reaches, if it ever does, the desired point; hence the weight felt, though a shorter course to run than in the second, is not increased by taking such a course. Of course, experiments can be tried at any point between the 1st and 3d experiments; but it will be observed, that the *quickness* with which weight is felt will bear a strict relation to the distance the gravitating body is placed from the occipital condyles, and also the *intensity of weight* experienced from any given body placed upon any of these parts, *cæteris paribus.*

The transit from the last experiment, where the superior maxillary bone was the resting point, to the inferior, is natural and easy. This bone, the inferior maxillary, articulates with the temporal bone in the glenoid fossa: between the head of the inferior maxillary bone and the fossa is placed an articular fibro-cartilage, on either surface of which is a synovial sac; but, as age advances, the fibro-cartilage mostly becomes absorbed towards its centre, and the synovial membranes are almost defaced at this point. The thinness and hardness of the fibro-cartilaginous disc makes this structure capable of transmitting force to the synovial membranes, without much interruption to their natural course. Moreover, if it did not so act, one membrane is always free to receive impressions from force channelling along the osseous tissue: since it is placed between two synovial membranes, both of which are placed in juxta position with the bony articular surfaces; hence any heavy body is felt when balanced on the chin, as well as elsewhere.

But it will be asked, why, if this bone has articular surfaces adapted to take cognisance of weight, do we not feel weight, of a greater or less degree, at all times when masticating food? It has been before stated, that a feeling of strength was the normal or *uncounterpoised* state of this sense, and that weight was the result of gravity *counterpoising* muscular force; now, the very end of mastication implies, *a priori*, that the thing acted upon is inferior, or in subjection, to the masticating power, or else why *attempt* to subject it to such a process? And, if subject to it, it cannot be upon a parity with it, or a counterpoise, but, so far as gravity at least is concerned, it must needs be considerably plus; and hence all feeling induced by, or connected with, counterpoise, must necessarily be wanting under such circumstances, and therefore, in partaking of food, vigour and strength ought (as they are), to be experienced, and not weight and labour.

I might remark that, in experimenting upon the chin, if a weight of 3 or 4 ounces be placed upon the chin, its weight will be quickly felt, but not to the same degree when the countenance is but slightly elevated above the natural erect position; but, if it is made to look directly upwards, the same weight will be felt much more intensely. This evidently arises from the same weight channelling its force onwards to the occipital condyles, whereby, by increased sentient surfaces presenting themselves, increased feeling of weight is experienced. Such incidental peculiarities are not to be altogether despised and rejected!

I shall pass over in silence the articulations of the clavicle, not from having neglected to experiment upon them, and that satisfactorily;

but any one who has carefully examined their synovial membranes, and also the very variable degrees of mobility different individuals possess in this articulation, will agree with me, that, from ordinary grounds of doubt, in articulations so variable as are these, experiments, as a test of correctness, or contrariwise, on any assumed hypothesis, are better avoided than pursued.

The shoulder-joint has already been examined and dismissed—the next in order, therefore, will be the elbow-joint. This joint is a compound one, the articulation of the ulna with the humerus being as perfect an example of a ginglymoid joint as the skeleton supplies; whilst the articulation of the radius with the humerus more closely resembles the enarthrodial order of articulation than any of the orders of articulation usually given in anatomical works.

In attempting to perform any experiment upon this joint, it will be well to remember the distinctive kinds of articulation the radius and ulna have with the humerus. With reference to the ulna, it is difficult to conceive how gravitating force would channel, if a weight were placed over the coronoid process, and how far it would affect the sigmoid notch, much less, if it were carefully analysed, would it be easy to describe the same: neither, again, is it an easy matter to place any weight over this part. Though, then, the writer has tried several experiments upon this articulation, with apparent success, yet, from the above reasons, he deems it wise to *avoid* giving any of them in detail, and will consequently direct attention to the radial articulation. This articulation being very simple, affords great facilities for retaining distinct the antagonising forces, muscular and gravitation.

One experiment will be sufficient for all practical purposes. Let the experimenter extend the arm and forearm, but not to perfect straightness or rigidity; at the same time let the hand be supinated, or in that position in which a large flat book would be balanced on the surface of the hand. In this position, place a book upon one of its angles, or any other suitable object, of 1 lb. to 2 lbs. weight, immediately over the radio-humeral articulation. This articulation in the extended arm is not just under the bend of the elbow, but about two-thirds of an inch in advance of it; and if this little point be not borne in mind an error in performing the experiment is very likely to occur. Supposing, then, the weight has been carefully adjusted, so that its gravitating force shall pass through the articulation, considerable weight will be felt; but if the same weight be placed one or two inches anterior to this point, whereby, from increased leverage, much greater weight ought to be felt, scarcely any will be felt, the same thing happens if it is placed *posterior* to this point; but this is what might be inferred as a natural consequence of diminished leverage. In the former position this objection cannot be urged. If, therefore, weight is felt more intensely over the articulation, than over that part where leverage gives such a decided advantage to the weight, it tenders to the fulcrum against which it rests, what is it but that, at the point over the articulation, the counterpoising forces can be brought into play where their resultant can best have applied, to sentient nerves there distributed, the stimulus their function naturally demands; which function, when thus stimulated, namely, by receiving the diagonal of two antagonizing forces, is manifested in the recognition of weight?

The last articulation to which I shall refer is the radio-carpal articulation, or the wrist-joint. This joint, like the elbow-joint, has no intervening articular fibro-cartilage, saving the triangular disc, between the cuneiform bone and the ulna; hence there is nothing to materially hinder the propagation of force in the same line of direction to that of the joint towards which it is tending. The carpal bones are small, well bound together by ligaments, and contain considerable hard compact tissue. The metacarpal bones also, with the phalanges, are well adapted to transmit force from their apices to the carpus, and thence to the synovial membrane of the joint. The synovial membrane is always well lubricated with synovia, is extensive, very complete in its continuity, and enjoys a high degree of sensibility to the slightest mechanical injury, or from the mildest form of inflammation that can affect that membrane. In every thing it is a joint well adapted to determine the correctness or validity of the present hypothesis. Again, between the ulna and cuneiform bone, there is a cartilaginous disc, covered with the same synovial membrane as the radial surface on one side, whilst the same disc is partially covered, and also the rounded head of the ulna, with the membrana sacciforma, on the opposite side; but this last named synovial membrane is very imperfect in many, and, in its location between the ulna and the fibrous disc, it is rarely found lubricated with synovia, or appears to fulfil the function of facilitating motion, but rather is lodged in this part as a point of attachment to retain it *in situ*, whilst the remaining part of the sac fulfils the function of aiding motion during pronation and supination between the radius and ulna, and is usually found slightly lubricated with synovia. These remarks, upon the membrana sacciforma, are made with the view of marking the contrast between the synovial sacs of the articulation of the inferior maxillary and the ulna, both of which have an inter-articular fibro-cartilage, and a double synovial membrane covering them; but the slightest reflection will immediately suggest the difference between the two, in extent, function, and sensibility.

This digression is not made without weighty reasons, since the writer is of opinion that the membrana sacciforma, in its relation to the head of the ulna, does not assist in the least in supplying consciousness of weight to this part of the wrist joint; and, moreover, that the triangular fibrous disc acts (as a damper in a piano-forte) in suppressing any consciousness of weight, arising from impressions made upon the principal synovial membrane of the joint, when this membrane, by inverting the hand, is placed in close contact with the cuneiform bone and the head of the ulna, whereby, when any weight is thrown upon this part of the articulation, consciousness of weight ceases to be experienced.

Without, then, making any further digressions, by soliloquizing upon the beauties and excellencies of that most perfect piece of mechanism, which either nature or art have completed—the hand—I will at once enter upon the detail of a few experiments.

Supposing I place in my hand a thick heavy book, say Ainsworth's Dictionary, I instinctively place the hand and forearm in one line of direction, and gently raise and depress the extremity, whereby a tolerable estimate of its weight is obtained. Again, if I still retain the book (elevated on the fingers and thumb), and *invert* the hand, as far as I conveniently can, taking care not to abduct the elbow, but retaining it at the same relative distance from the side of the body, I shall find the amount of weight at first experienced to be considerably diminished. To perform this experiment without raising and depressing the hand and forearm is the best.

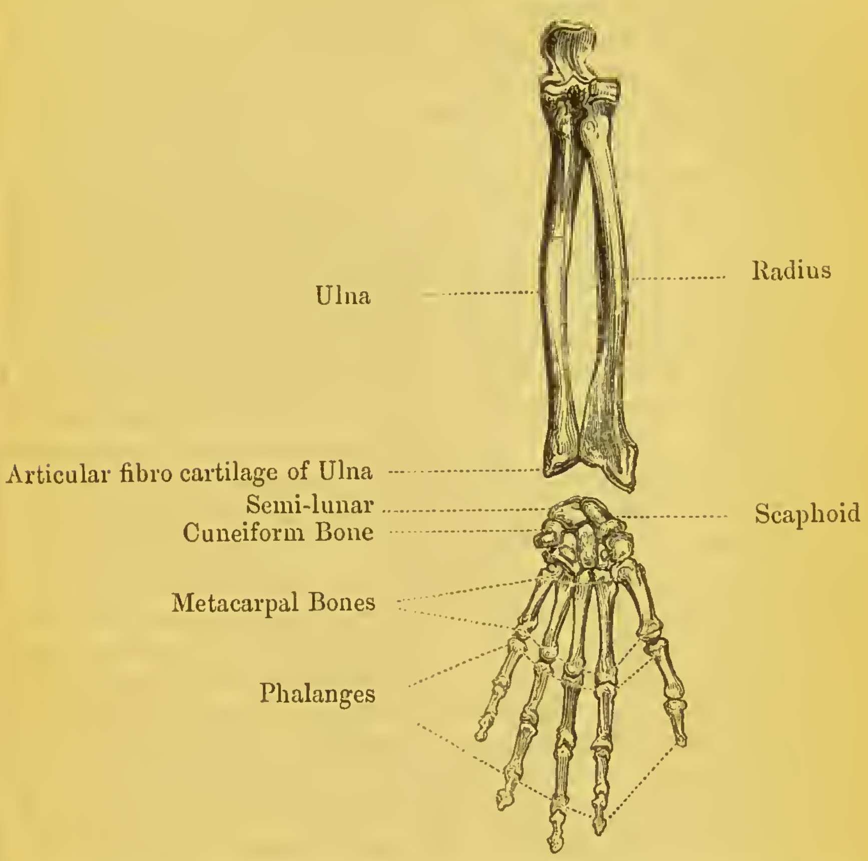
But, in place of holding upon the hand a considerable weight, suppose a halfpenny or a shilling be placed upon the fingers, I shall instinctively *invert* the hand; but supposing that volition overcomes instinct, and the hand is extended in a *straight* line with the forearm, as in the first experiment, all feeling of weight will disappear, and especially if the hand is, of the two, rather everted.

Now, in place of slightly everting the hand, let the hand be inverted as much as can be accomplished with convenience, and the shilling be placed with the fingers slightly flexed, between the third and little finger, and the hand be gently raised and depressed, or rather gently raised and quickly depressed, when more weight will be experienced than in any other position in which the weight can be placed in the hand.

Here, then, are four experiments: with the first, by having the hand extended in a straight line with the forearm a large weight is well and easily discerned; but in the third experiment, with the hand still retained in the same position, a very small weight scarcely can, if at all, be discerned. Again, by inverting the hand, the larger weight, as in the second experiment, is less perfectly estimated and felt; whilst, as in the fourth experiment, by retaining the hand in that position, the smaller weight is well discerned, and the more it is inverted, without inconvenience to the experimenter, the greater is the feeling of weight experienced.

How, then, are these contrasts to be explained? With the larger weight, as in the first and second experiments, there is little difficulty in readily comprehending the rationale; thus, when the hand is extended in a straight line with the forearm, the scaphoid and semi-lunar bones, which articulate with the radius, are placed in exact opposition to each other, and, consequently, there is a large free surface of synovial membrane, well adapted to receive force, in any direction in which it may be tendered from the hand, impressed with the resultant force of two antagonizing forces, whose course, in their common diagonal, is the natural stimulus, in the nerves there distributed, to excite in them the sense or feeling of weight; therefore, according to all fair modes of reasoning, when the hand is thus placed in relation to the forearm, weight ought to be well estimated.

Fig. 5.[1]



But for the same reason that, in the first instance, weight ought to be easily and well estimated, in the latter it ought not so to be; since, by inverting the hand, the scaphoid and semi-lunar are not so closely approximated to the radius as is the cuneiform with the ulna, and, consequently, the chief synovial surface is very imperfectly impressed with its appropriate stimulus, and therefore the amount of weight experienced is less marked and evident (*vide* fig. 5).

The third and fourth experiments cannot be so easily explained, but, I think, quite as satisfactorily; but to arrive at a correct explanation more analysis is required. All facts are not equally evident; some are known as much by the absence of one class of facts or phenomena, as by their own actual presence: thus, the shining of the stars by day is as certain as that of the sun's; but the very existence of stars, were it not for the absence of the sun, would never have been detected; and by day they can only be seen by such instruments as exclude, in part, the sun's rays. Again, in chemical analysis the effects of chemical re-agents, where the agent to be acted upon is in very minute quantities, are so slight that their action might be altogether questioned, were it not for the fact that the re-agent, with the agent, can be contrasted with pure water to which the re-agent only has been added, when the difference is evident; but without such contrast, so slight is the change produced upon any given agent, when in very minute quantities, by the re-agent, that its presence or absence could not be satisfactorily determined. Such, then, is exactly the case in the two last experiments recorded. How a very minute weight is tested best by the hand being inverted, arises from *all weight being entirely absent* when the hand is gently raised, and pressed against the inter-articular cartilage of the head of the ulna, by inversion; but by rather quickly *depressing* the hand, the cartilage is gently compressed, and the hand in falling downwards naturally turns a little outwards, and so the articular surfaces of the scaphoid and semi-lunar approximate the radius, and thus induce a feeling of weight, by impressing a larger synovial surface gently and feebly, but certainly; whilst, when this pressure is taken off, by elevating the hand again, *during the act of elevation*, the feeling of weight is *suspended.* It is a curious fact, also, and worthy of great attention, that if the hand alone, or with a slight weight, be long gently elevated and depressed, whilst *inverted,* to assist the *eversion,* when the hand is depressed, and so enable the free articular surface of the radius to be gently counterpoised by the opposing carpal bones, that *the whole of the thumb becomes congested and loaded with blood,* whereby the external part of the hand is made heavier than the internal, and in the act of depressing the hand greatly assists in its very slight eversion, as a natural consequence of gravity acting from that point. Therefore the feeling of slight weights, when the hand is inverted, is not owing to the hand being better able to feel weight in the inverted position than in the straight position; but from the fact that very slight weights are scarcely discernible to the sense of force, and the only way of proving the presence of weight is to contrast the feeling experienced by its *entire absence,* as compared with its most limited, or minute, presence. Such an explanation, with such a contrast, whilst it is quite in accordance with correct anatomy and physics, cannot, I think, be legitimately explained upon a more definite basis than that herein assumed.

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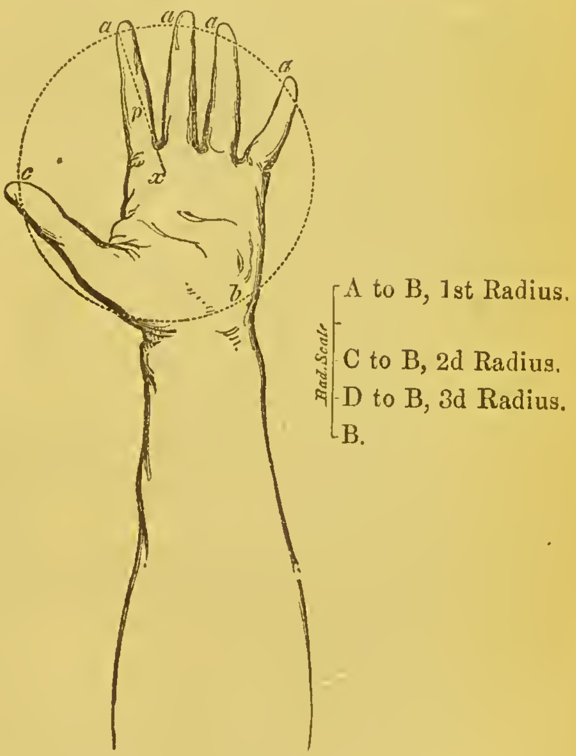
[1] I desire to express my thanks to my talented professional brother, Mr W. K. Parker, Pimlico, for the etching of the first five figs., and to Mr Knight, artist, Clarendon Street, Pimlico, for figs. 6 and 7.

I shall now give my last written experiment, but my first practical, which led to the investigation of which this paper may be termed the chief summary.

Let the forearm be placed at nearly right angles to the arm (or humeral division), with the hand extended, and the fingers and thumb semi-flexed, the *first* phalanges being but very slightly flexed. In this position let a book about the size and thickness of "Whewell's Bridgewater Treatise," be placed upon the tips of the fingers and thumb, taking care to let each member distinctly touch the book. This being done, after having gently raised and depressed the book, for the purpose of weighing it, carefully remove it, taking care at the same time to retain in their exact sites the thumb and fingers. Whilst thus retained place a pair of compasses, with the point of one shaft over the transverse ligament, binding the heads of the index and middle fingers, and extend to the tip of the index finger the point of the opposing shaft. With the compasses thus adjusted describe a circle, whose centre, x, shall be over the transverse ligament before referred to, and whose circumference shall pass over, in order, the tips of all the fingers, the *base* of the metacarpal bone of the little finger, and the pad of the thumb (for no weight naturally rests upon its tip).

FIG. 6.

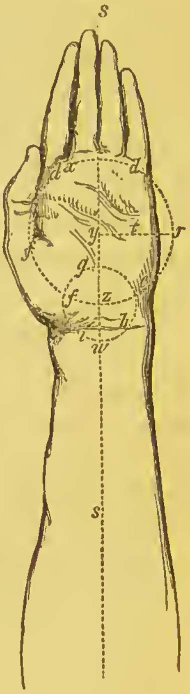


But to better apprehend this description, instead of continuing to burden the memory, where abstraction is chiefly required, I will endeavour to explain it by diagrams, with the aid of geometrical precision, rather than anatomical detail, as far as the subject permits.

Let a book be balanced on the tips of the fingers and pad of the thumb, and when removed let the various parts be retained *in situ*, as in fig. 6. Thus adjusted, describe the circle *a*, *a*, *a*, *a*, *b*, *c*, which shall respectively pass over the tips of the fingers *a*, *a*, *a*, *a*, the base of the metacarpal bone of the little finger, *b*, and the pad of the thumb, *c*, and whose centre, *x*, shall be immediately over the transverse ligament between the heads of the first and second metacarpal bones.

Let any radii of the circle *a*, *a*, *a*, *a*, *b*, *c*, be bisected at equi-distance from either terminal point, as the radius *x*, *a*, at the point *p*, then the bisected radius, from either terminal point, as at the points *x*, *p*, shall be the extent of any radii of a second circle, *d*, *d*, *e*, *f*, *f*, passing over (when the fingers and thumb are brought together, with the hand extended), in order the metacarpo-phalangeal articulations of the index and little fingers, *d*, *d*, the base of the metacarpal bone of the little finger, *e*, and, less perfectly, over the base and head of the metacarpal bone of the thumb, *f*, *f*, and whose centre shall be *y*, situated near the centre of the hand, between the metacarpal bones of the second and third fingers.[1] (*Vide* fig. 7.)

FIG. 7.



Let a straight line, *s*, *s*, be drawn between the second and third fingers, over the palm of the hand and the wrist, to three or four inches, or less, midway between the radius and ulna, over the interosseous ligament. This line shall intersect the circle, *d*, *d*, *e*, *f*, *f*, whilst crossing the wrist at the point *z*.

The point *z* shall be the centre of a third circle, *g*, *h*, *i*, the extent of whose radii shall be equal to any radii of the circle *d*, *d*, *e*, *f*, *f*, *bisected* at equi-distance from either terminal point; as the radius *y*, *r*, bisected at the point *t*.

Where the circle, *g*, *h*, *i*, intersects the straight line, *ss*, at the part farthest from the fingers shall be the point desired, *w*, being immediately over that part where gravity, from a book, etc., will pass through the wrist-joint.

After having given these successive proportions, it may be said, Why not feel for the joint at once, and so settle the matter? In reply, I may state that, as yet, we have not got quite through the experiment; when it is completed we shall be better able to measure the importance of the point, *w*, so obtained.

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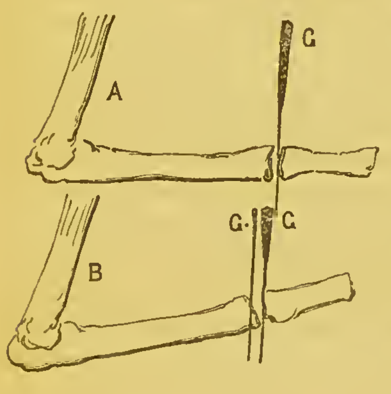
[1] The centre, *y*, is best attained after having adjusted the compass to the points *x* and *p*, by retaining one shaft of the compasses on the point *x*, and revolving it till the opposite shaft has attained the anatomical seat indicated.

The point *w* being now attained mark it with ink, and then *re-weight* the book as at the first; after having carefully estimated its weight in the mind remove it, but let the fingers and thumb be retained *in situ*, and then balance the book upon one of its corners, at the point *w;* at this point the book will weigh as heavy, or rather heavier, than when balanced on the fingers and thumb. If, then, at this point there was not some special provision for taking cognizance of gravity when placed as a counterpoise to muscular force, it is impossible to conceive how a weight, with so much increased leverage at the extremities, should weigh as heavy, or heavier, at this point, unless at this point the resultant of two forces is more directly applied to the sentient nerves recognizing this property in matter—weight, than at the tips of the fingers and thumb, where, if it have to travel to the chief joint before truly recognised, must lose much of the original force by friction and composition, and, consequently, be less perfectly felt than where, from its proximity to the sentient membrane, or nerves, such expenditure of force will not take place.

It must be observed that, if the book be placed anterior or posterior to the point *w*, the weight felt will be considerably less than at this particular point, *the hand and fingers being preserved in their original position.* Of course this check to the experiment only tends to confirm the previous inference.

Why it is better to place the book upon the point *w*, and not directly over the joint, *as determined by feeling* at the wrist, arises from the fact that, in balancing a book upon the fingers and thumb, the hand and forearm are either kept in a line at right angles with the arm, or else adjust themselves to a line more or less acute to that part: in one man, the ability to weigh with comfort is obtained by the hand and forearm naturally assuming one position with regard to the arm; whilst, in another, a *slightly* different position is assumed; and according to the position of the forearm and hand to the arm, so must the weight be placed exactly over the joint, or half a line to two lines anterior to this part, for the gravity to pass through the greater part of the joint, or sentient surface, as is illustrated in the etchings, A and B, where gravity, G, is represented as passing through the joints at variable angles, according to the degree of flexion of the forearm upon the arm.

Fig. 8.



It will be asked again, But do not different individuals present very different proportions in their hands, let them be adjusted in whatever way it may be thought proper to measure their dimensions? To this I must reply by saying, that where the hand is not much used in severe hard labour, very little difference will be found in the most delicate hand, or the strongest, in the proportions here given, when the hand is properly adjusted—the little finger being the member most usually out of proportion, and perhaps all in a family will have the same peculiarity, yet this is any thing but common. The left hand, as a rule, is the best to measure from; this hand being generally least exposed to injury from severe or constant pressure, etc.

Before closing my remarks upon the hand, perhaps it will not be deemed unbecoming, though not directly related to the subject here discussed, if I give one or two measurements of the thumb in relation to the hand, in as few words as the subject will permit—a well proportioned hand being here assumed.

With a pair of compasses measure from the base of the metacarpal to the head of the first phalangeal bones of the thumb—the dorsal side is the best to measure from. Adjust the compasses, by one shaft, over the base of the metacarpal bone of the thumb on the *palmer* side, and with the free shaft describe a circle; the same shall pass over the metacarpo-phalangeal articulations of the index and little fingers. Next, extend the hand, approximate the fingers, but *abduct* the thumb: with the compasses adjusted as at first, place the point of one shaft on the outer, or radial side of the metacarpo-phalangeal articulation of the index finger, with the free shaft describe a circle, which shall pass over the thumb and little finger opposite their nails. Lastly, with the hand extended and fingers closed, adjust the compasses *across* the palm of the hand, parallel with the metacarpo-phalangeal articulations, when the first, or thumb measurement, shall be equal to the last. As it is not the design of this paper to enter upon the mechanism of the hand, I shall not press any inference from the above measurements, but leave the same to better and more able hands than mine. Yet I would suggest to any who might be so disposed, that in deducing inferences from the measurements of the thumb, it will be convenient to view the thumb from the metacarpal to the first phalangeal bones as a *moveable fulcrum*, and the *last* phalangeal as the lever.

In the foregoing sketch scarcely any thing has been said of the sense of force in relation to the feeling of *resistance or strength*, neither is it deemed suitable to make any lengthened remarks upon this feeling, when we consider that vigour or strength is the *normal* state of this sense in health, since muscular force, whilst unantagonised by gravitation (saving that pertaining to the limbs themselves), naturally channels along the osseous structures, through the joints, in that direction best adapted to excite the feeling of resistance or strength. Whilst, on the other hand, if a weight be placed upon any of the parts already indicated in making experiments for weight, and in place of using muscular force *sufficient* to counterpoise the imposed weight, that muscular force is considerably *plus* over the gravitation (from rigidly contracting the muscles), then the gravitating force will be brought to composition and resolution ere it reaches the joint, and therefore muscular force will alone remain, and will produce a feeling of vigour and strength in proportion to the amount of muscular contraction plus over the gravitation. The careful weighing of a book in the hand, and afterwards, with the same book in the hand, rigidly extending the arm and hand, will make apparent what is here desired to be understood. In weighing the book *little* muscular force is used to counterpoise gravity, and weight is the feeling induced; but when *much* muscular force is used, a feeling of vigour or strength follows, from the muscular force being considerably plus over the gravitating force. Of course the lines of direction in the two different feelings experienced—weight and resistance—will be in conformity with those maintained for the respective feelings at the commencement of this paper.

If very great muscular exertion is used to overcome gravitation, with a considerable plus of muscular force, there is a feeling or sensation over and above that of mere vigour, namely, a feeling of violent exertion distinct from either mere resistance or weight; this sensation arises in all probability from some other sentient impression than that of force only.

Having thus feebly finished the task I allotted to myself at the commencement of this paper, it is not becoming in me here to make any general remarks upon the application of the sense here advanced; for that would be premature whilst it is, as yet, *sub judice.* Moreover, this paper has only reference to the distribution of this sense to synovial membranes, but the writer is disposed to think that this sense has other seats of distribution besides that of synovial membranes, which will require a very careful examination in connection with several collateral subjects, which bear a nearer or more remote relation to the sense discussed.

The only thing the writer can with propriety at present refer to, is the testy subject of the *substratum* of matter; or, that there is something pertaining to matter of which neither sight, touch, nor smell, etc., can give us any information, these having relation to the superficies, yet it is evident that these are so many indications of its existence—the feel, colour, angles, etc., but not the substance; yet the fact that we are sure that these are the superficies, and not the substance of the same, arises from our consciousness of its possessing *weight.* And how? Because, though we cannot touch it, hear it, see it, smell it, or taste it, yet we can *feel* weight. And how do we feel it? Not, surely, because it is unrecognisable by any of our senses, or else how should we feel it? And if we feel it, and yet none of the recognised senses inform us of the presence of this said substratum, it remains, therefore, that a sense yet unrecognised gives us that assurance which the rest have failed to detect, and that that sense must embrace within its function the ability to detect weight. This, certainly, always assures us of the presence and amount of matter, or of its untouchable substance, or substratum, which none of the orthodox senses have been able to detect, neither can they.

But, it will be said, that the philosophers and metaphysists do not affirm weight to be that elemental property in matter which gives to the examiner the conviction of the existence of a substratum which the orthodox senses cannot recognise. This I freely admit; yet I am disposed to think that the usual mode in which the subject is argued and referred to implies a conviction, arising from some impression matter gives to the philosopher distinct from the five recognised senses, and not having wherewith to express his inward impressions of the same, has recognised that conviction by the term substratum, which weight would have expressed *equally as well and more concisely*. Nevertheless, let it be granted that that elemental property in matter, called weight, does not include all that is implied by the term substratum (I mean when the term is used correctly), yet, if we had no sense capable of recognising *weight* and *resistance* in matter, those very characters, as weight and resistance, as distinct from roughness and smoothness, which above all others assure us of its presence and mechanical properties, would leave us in a perfect chaos of ignorance, both as how to use and apply matter, and whence it was governed, and what laws it obeyed,—direct revelation being in such case necessary for our subsistence and guidance.

WARWICK STREET SOUTH, PIMLICO,
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